



Executive Summary

*Jennifer M. Larson
Robert J. Harrach*

Introduction

Lawrence Livermore National Laboratory (LLNL), a U.S. Department of Energy (DOE) facility operated by the University of California, serves as a national resource of scientific, technical, and engineering capabilities. The Laboratory's mission focuses on nuclear weapons and national security, and over the years has been broadened to include areas such as strategic defense, energy, the environment, biomedicine, technology transfer, the economy, and education. The Laboratory carries out this mission in compliance with local, state, and federal environmental regulatory requirements. It does so with the support of the Environmental Protection Department, which is responsible for environmental monitoring and analysis, hazardous waste management, environmental restoration, and assisting Laboratory organizations in ensuring compliance with environmental laws and regulations.

LLNL comprises two sites: the Livermore site and Site 300. The Livermore site occupies an area of 3.28 square kilometers on the eastern edge of Livermore, California. Site 300, LLNL's experimental testing site, is located 24 kilometers to the east in the Altamont Hills, and occupies an area of 30.3 square kilometers. Environmental monitoring activities are conducted at both sites as well as in surrounding areas.

This summary provides an overview of LLNL's environmental activities in 1998, including radiological and nonradiological surveillance, effluent, and compliance monitoring, remediation, assessment of radiological releases and doses, and determination of the impact of LLNL operations on the environment and public health.

Environmental Monitoring Results

During 1998, the Environmental Protection Department sampled air, sewerable water, ground water, surface water, soil and sediment, and vegetation and foodstuff. Samples were analyzed for radioactive and nonradioactive substances using (1) standard methods approved by the U.S. Environmental Protection Agency (EPA), (2) special systems such as the continuous monitoring system for Livermore site sewage, or (3) special analytical techniques designed to measure very low levels of radionuclides. Environmental



radiation was also measured directly using dosimeters. Over 15,000 environmental samples were taken, and results were obtained for more than 244,000 analytes.

Air Monitoring

Air was monitored for various airborne radionuclides (including particles and tritiated water vapor) and beryllium at the Livermore site, Site 300, and off-site locations throughout the Livermore Valley and Tracy area. Concentrations of all monitored radionuclides and beryllium at all of these locations were well below levels that would endanger the environment or public health according to current regulatory standards. For example, in 1998, the highest median plutonium concentration for samples collected at any air monitoring station was 0.0021% of the federal Derived Concentration Guide (DCG). The DCG specifies the concentration of radionuclides in air or water that could be inhaled or ingested continuously 365 days a year without exceeding the DOE radiation protection standard for the public. Median concentrations of tritiated water vapor collected at Livermore Valley sampling locations showed a highest median value of 0.0007% of the DCG, while the highest median values on the Livermore site perimeter and within the site boundaries were, respectively, 0.005% and 0.5% of the DCG. The highest median concentrations of beryllium on the Livermore site and Site 300 were both 0.1% of the guideline level established by the Bay Area Air Quality Management District and the EPA and are representative of naturally occurring levels.

Stack Air Effluent Monitoring

In 1998, LLNL operated 101 samplers for measuring radioactivity in air effluent at eight facilities at the Livermore site. These samplers extract a measured volume of air from the exhaust stack of a facility or process and collect particles or vapor in a collection medium. Measured radiological air emissions from Livermore site operations remain well below levels of health and environmental concern. Building 331 emissions accounted for 72% of the estimated total tritium emissions from the site in 1998; emissions from this facility remain at a level far below those of the 1980s and cause public dose impacts far below levels allowed by regulatory standards. Radionuclide emissions from the other monitored facilities were very low.

Nonradioactive air emissions from exempt and permitted sources at LLNL were quite small and typical of values in previous years. For example, total emission of nitrogen oxides from the Livermore site in 1998 was about 56 kg/day, which is 0.006% of the quantity of this air pollutant released daily over the entire Bay Area; corresponding numbers for reactive organics were 25 kg/day and 0.02%. The total emission of criteria



air pollutants (nitrogen oxides, volatile organics, sulfur oxides, particulate matter, carbon monoxide, and lead) was approximately 100 kg/day for the Livermore site and about 25 times smaller for Site 300.

Sewerable Water Monitoring

Discharges of radioactive and hazardous material to the combined sanitary and industrial sewer at the Livermore site are controlled by use of administrative and engineering controls, including limiting the disposal of those materials, and routing some discharged material to retention tanks for later characterization and treatment. Flow-proportional and instantaneous samples of discharged wastewater are regularly collected and analyzed (for metals, radioactivity, toxic chemicals, and water-quality parameters) to assure that LLNL's sewage effluent meets the requirements of the permit granted by the City of Livermore. In addition, the site effluent is monitored continuously for pH, regulated metals, and radioactivity. If concentrations are detected above warning levels, an alarm sounds and the effluent is automatically contained by LLNL's sewer diversion system. The diversion system captures all but the initial minutes of wastewater flow that causes an alarm, thereby protecting the Livermore Water Reclamation Plant (LWRP) and minimizing any required cleanup. With the 1998 addition of a new monitoring and diversion capability for pH, even the initial minutes of a pH-related release are contained on site.

In 1998, the Livermore site discharged an average of 0.95 million liters per day of wastewater to the City of Livermore sewer system, an amount that constitutes 4.0% of the total flow to the system (about 14% of the Livermore site effluent was generated by Sandia National Laboratories/California). The Livermore site's sanitary sewer effluent is monitored continuously and sampled daily, weekly, and monthly to satisfy various permit compliance requirements.

LLNL achieved 100% compliance during 1998 with LWRP permit limits covering discharges into the City of Livermore's and LLNL's sanitary sewer system. In 1998, no sewer releases exceeded discharge limits for radioactive materials.

Surface Water Monitoring

Surface water sampling and analysis are a large part of the LLNL surveillance and compliance monitoring effort for the Livermore site, Site 300, and their surrounding regions. The waters monitored include storm water (runoff water), rainfall, water in the Livermore site Drainage Retention Basin, wastewater discharges from cooling towers at



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Site 300, and a variety of other waters that include reservoirs and ponds, drinking water taps both on and off site, and the Livermore site swimming pool.

To evaluate the overall impact of LLNL operations on storm water quality, storm water is sampled where it enters and where it leaves the site. In the 1997/1998 rainy season, tritium was found to be higher in effluent water than in influent water. The maximum tritium activity in all storm water was still only 4% of the amount of tritium California allows in drinking water (referred to as the maximum contaminant level or MCL). In addition, maximum gross alpha and gross beta activities in storm water were 68% and 17% of their respective MCLs. Although aluminum, iron, lead, manganese, and zinc were also found to be higher in effluent than influent storm water and above criteria set by either EPA or the Regional Water Quality Control Board, fish toxicity tests conducted in 1997 for the 1997/1998 wet season indicated that LLNL storm water runoff had no adverse impact on off-site biota.

The highest tritium activity measured in rainwater was 23% of the tritium MCL, and the highest tritium activity measured in surface water bodies was 1% of the tritium MCL. In drinking water sources, the highest tritium activity measured was 0.03% of the MCL. A person drinking 2 liters of water per day for a year at the highest level measured in drinking water would receive 0.06% of the DOE standard allowable dose of 0.04 millisieverts (4 millirems) for drinking water systems. The sampling data indicated that operations at the Livermore site had a negligible impact on surface and drinking waters.

Ground Water Monitoring

Ground water in the Livermore Valley and the Altamont Hills is monitored to assess the progress of remediation efforts in areas of known contamination, to test the impact of LLNL operations on local water sources, and to comply with numerous federal, state, and local permits. Ground water samples are routinely measured for tritium, uranium, and other radioisotopes; gross radioactivity; toxic metals; a wide range of organic chemicals; and other general contaminant indicators. Special consideration is given to monitoring those dissolved elements and organic compounds that are known to be toxic in trace amounts.

The impact of Livermore site and Site 300 operations on off-site ground water continued to be minimal in 1998. In the Livermore Valley, no monitored radioactive or inorganic nonradioactive constituent was found to exceed primary drinking water MCLs in any off-site well. In on-site wells, chromium and nitrates have been detected above the primary MCL, but these constituents have not migrated off site. The maximum tritium



activity detected in any sample of ground water measured in the Livermore Valley was 1.5% of the MCL, as measured at an on-site location. At Site 300, tritiated water and depleted uranium have been released to ground water from landfills and firing tables, but the boundaries of the slowly-moving ground water plumes lie entirely within site boundaries. The shallow ground water beneath Site 300 contains volatile organic compounds (VOCs), tritium, nitrates, Freon, and depleted uranium, but presents no current health risks because this contaminated water is not used as a potable domestic, livestock, or industrial water supply and presents no other pathways to environmental receptors. LLNL works with the regulatory agencies to contain or cleanup ground water contamination, where needed.

Soil and Sediment Monitoring

The impact of Laboratory operations on soil and sediment at the Livermore site in 1998 was insignificant and unchanged from previous years. The highest level of plutonium (isotopes 239 and 240), measured at the LWRP, represented 1.6% of the EPA preliminary remediation goal for commercial or industrial sites. Other constituents of concern were measured at background or trace concentrations or were below the limit of detection. At Site 300, the concentrations of radionuclides and beryllium in soil samples were generally representative of background or naturally occurring levels, as in previous years. Elevated concentrations of uranium-238 found in Site 300 soils in 1998 were attributed to contamination by debris from firing-table experiments.

Sampling of soil below the surface but above the water table (vadose zone), which was carried out as part of the Livermore Ground Water Management Program, showed that ground water on the Livermore site is not being affected by contaminants carried in storm water.

Soil was sampled at Big Trees Park in Livermore during August and September of 1998 to provide information about the vertical and lateral distribution of plutonium in the soil, the pathway by which plutonium got to the park, and distribution of plutonium in areas of public concern. All sample results indicated that plutonium concentrations were below the risk-based preliminary remediation goal for residential areas. Pathway analysis indicates that plutonium most likely reached the park in the sewage sludge that was used as soil amendment. The EPA, the California Department of Health Services, and the Agency for Toxic Substances and Disease Registry all concurred that there was no unacceptable risk to human health or the environment from the levels of plutonium present at Big Trees Park.



Vegetation and Foodstuff Monitoring

LLNL impacts on vegetation and food in the Livermore Valley remained minimal in 1998. Tritium, which is the radionuclide of most interest in the vegetation and foodstuff monitoring program, was estimated to be well below levels of concern, even when organically bound tritium was taken into account. In 1998, as in the past, tritium concentrations in Livermore Valley wines were slightly above those for wines tested from Europe and other locations in California, but the tritium levels were quite low. Mean levels for the 1998 sampling year, using data from all areas, were not significantly different from those reported for the past several sampling years. Even the highest detected tritium value represented only 1.1% of the amount of tritium California allows in drinking water (no health standards exist for radionuclides in wine).

Radiological Dose Assessment

Radiological dose-assessment modeling—using conservative EPA-mandated computer models, actual LLNL meteorology, population distributions appropriate to the two sites, and 1998 radionuclide usage inventory and monitoring data—was conducted this past year for key facilities. Emissions from more than 200 points were reported in 1998. These sources were of several types: stacks and other exhaust pathways from buildings, diffuse area sources generally external to buildings, and open-air firing tables at Site 300 where explosives experiments were conducted.

LLNL reports public doses resulting from air releases of radionuclides during routine operations and from accidents. The principal exposure pathways taken into account are internal exposures from inhalation of air and ingestion of foodstuff and drinking water contaminated by the air releases. Releases of radioactivity from LLNL via water do not directly contribute to the public dose, because this water is not used as a potable domestic or industrial water supply or for agriculture.

The most significant radiological effluent for the Livermore site from the standpoint of public dose continues to be tritium, the radioactive isotope of hydrogen. The calculated total potential dose for the sitewide maximally exposed individual (SW-MEI), (i.e., a hypothetical member of the public having the greatest possible exposure from Livermore site operations in 1998) was 0.49 microsievert (0.049 millirem). This is about half of last year's total, reflecting decreased emissions from the stacks of the Tritium Facility. This result was calculated based on LLNL's standard assumptions regarding potential public dose caused by tritium releases from these stacks. In 1998, the EPA mandated that LLNL's compliance evaluations use a more conservative assumption, in which gaseous tritium is to be treated as though it were tritiated water vapor. This resulted in a 12% higher dose or 0.55 microsievert (0.055 millirem) to the



SW-MEI. Trends in this SW-MEI dose for the Livermore site over the last seven years show levels in the range 1.0 to 0.4 microsievert/y (0.1 to 0.04 millirem/y), down from 2.40 microsievert/y (0.24 millirem/y) in 1990. These small radiation quantities exhibit large percentage but small absolute value fluctuations from year to year.

At Site 300, depleted uranium (containing isotopes with atomic weights 238, 235, and 234) remains by far the principal contributor to off-site dose. The calculated total potential dose to a hypothetical public individual having the greatest possible exposure at Site 300 during 1998 was 0.24 microsievert (0.024 millirem), which is slightly higher than in 1997 but still well within the range of concentrations measured over the past nine years.

Conservatively calculated radiological doses to the maximally exposed public individuals from Livermore site and Site 300 emissions amounted to about 0.49% (0.55% using EPA assumptions) and 0.24%, respectively, of the EPA National Emission Standards for Hazardous Air Pollutants (NESHAPs) regulatory standard. These doses are a small fraction (about 1/6000) of the doses received by these populations from natural background radiation. Thus, the potential radiological doses from LLNL operations in 1998 were well within regulatory limits and were very small compared to doses from natural background radiation sources.

Environmental Compliance and Program Activities

LLNL works to ensure that its operations comply with all environmental laws and federal, state, and local regulatory guidelines. Many activities related to water, air, waste, waste reduction, community "right to know," and other environmental issues were addressed in 1998.

Ground Water Remediation

As a Superfund site, LLNL continued to treat ground water at both the Livermore site and Site 300 under the jurisdiction of the Comprehensive Environmental Response, Compensation and Liability Act. LLNL's primary treatment method to remediate contaminated ground water is pump-and-treat technology. In 1998, nearly 150 kilograms of VOCs plus smaller quantities of dissolved fuel hydrocarbons were removed from almost a billion liters of ground water and 140,000 cubic meters of water vapor from soil at the Livermore site. These efforts at control and remediation have reduced VOC concentrations throughout the site, stopped the off-site westward migration of VOC plumes from the Livermore site, and reduced plume sizes.



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Significant progress occurred in the TF5475 area, where both tritium and VOCs are present in the same hydrostratigraphic unit. TF5475-1 was activated in 1998 to treat VOCs in ground water while keeping the tritium in the subsurface layer. TF5475-1 uses down-hole, in situ catalytic reductive dehalogenation to treat VOCs in ground water. A mathematical model of the T5475 area was developed to evaluate potential extraction and injection well configurations to improve overall remediation performance.

Significant progress was also made at Site 300, where 22 kilograms of VOCs were removed from soil and ground water in four treatment areas. In the Eastern General Services Area, the plume of high trichloroethene concentrations was reduced by 1400 m and now extends only 30 m beyond the site boundary.

Treated ground water discharges and VOCs vented to air all were within permit limits during 1998.

Waste Minimization and Pollution Prevention

LLNL continued to employ a weighted ranking system to prioritize and evaluate its waste streams. Cost, type of waste, and operational aspects were emphasized rather than simple considerations of total waste volume. Transuranic and transuranic-mixed and low-level wastes continued to be of highest priority for LLNL, even though their relative quantities were low.

Comparing 1998 to the 1993 baseline, levels of waste in three of the four categories—radioactive, hazardous, and sanitary—continued to decrease. However, in 1998, levels of mixed waste did not diminish because increased quantities of low-level mixed waste were processed with the result that increased quantities of solid, low-level mixed waste were produced. The total waste diverted from landfills in 1998 was more than 30,000 tons, significantly less than the diversion total for 1997, but comparable to the 1996 total. The high quantities of waste diverted in 1997 predominantly resulted from the reuse of large quantities of soil from the construction of the National Ignition Facility. LLNL's recycling percentage for nonhazardous waste was 87% in 1998, far in excess of the DOE's stated 1999 goal of 33%.

ChemTrack, LLNL's computerized chemical inventory system, tracked 178,000 chemicals in 1998 through the use of bar codes, hand-held bar code laser scanners, and customized software.



Air, Wastewater, and Water Compliance

LLNL continued to perform all activities necessary to comply with clean air and clean water requirements. In 1998, the Bay Area Air Quality Management District issued or renewed 138 operating permits for the Livermore site. The San Joaquin Valley Unified Air Pollution Control District issued or renewed 47 permits for Site 300 operations. LLNL has permits for underground and aboveground storage tanks and for discharge of treated ground water, industrial and sanitary sewage, and storm water. Site 300 has additional permits for inactive landfills, cooling tower discharges, operation of the sewer lagoon, septic tanks, and leach fields. The Laboratory complies with all requirements for self-monitoring and inspections associated with these permits.

Environmental Occurrences

Notification of environmental occurrences at the Laboratory is required under a number of environmental laws, regulations, and DOE orders. LLNL responded to five incidents that required federal and/or state agency notification during 1998. None of these caused adverse impact to human health or the environment.

Endangered Species

LLNL meets the requirements of both the U.S. Endangered Species Act and the California Endangered Species Act as they pertain to endangered or threatened species and other species of special concern that may exist or are known to exist at the LLNL sites. In 1998, biological assessment surveys were performed for special-status species at 51 LLNL project construction (ground disturbance) areas. Although no active San Joaquin kit fox dens were discovered, four occupied American badger dens were found. In addition, 12 active burrowing owl dens and a population of the federal candidate species California tiger salamander (*Ambystoma tigrinum*) were discovered at Site 300. A new population of the federally threatened red-legged frog (*Rana aurora draytonii*) was identified in the northwestern portion of Arroyo Las Positas on the Livermore site. Measures to mitigate the potential for future impacts to the frogs were developed in conjunction with the U.S. Fish and Wildlife Service. Also at the Livermore site, six separate pairs of white-tailed kites (*Elanus leucurus*), a state-protected raptor, successfully nested and fledged 14 young.

Two of the three known natural populations of the large-flowered fiddleneck (*Amsinckia grandiflora*), a federally listed endangered plant species, occur at Site 300, where a portion of the site has been designated as critical habitat for the plant. In spite of



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attempts to reduce exotic ground cover with herbicides, the number of native plants dropped by 42% in 1998. Investigations into the use of herbicides, controlled burns, and native bunch grass transplantation to reduce the amount of exotic grass cover are currently underway.

Monitoring of the big tarplant (*Blepharazonia plumosa*), a California Native Plant Society "rare" plant), and the Diamond-petaled poppy (*Eschscholzia rhombipetala*), a plant not seen in California since 1950) continued in 1998. The big tarplant continued to be widespread throughout Site 300. A total of 26 diamond-petaled poppy plants were located; of these, 18 plants produced seed-bearing pods.

Conclusion

The current techniques used at LLNL for environmental monitoring are very sensitive, allowing detection of extremely low levels of constituents. The combination of surveillance and effluent monitoring, source characterization, and computer modeling show that radiological doses to the public caused by LLNL operations are less than 1.0% of regulatory standards and are about 6000 times smaller than the doses received from background radiation. The analytical results and evaluations generally show continuing low contaminant levels, reflecting both decreased operations and the responsiveness of the Laboratory in controlling pollutants.

In 1998, LLNL successfully engaged in environmental compliance activities related to water, air, waste, and waste reduction. Ground water remediation activities stopped the westward migration of plumes at the Livermore site, waste minimization efforts reduced the amount of waste generated in LLNL operations, and recycling efforts diminished the quantity of waste sent to landfills. Actions to protect endangered species at both LLNL sites continued on several fronts.

In summary, the results of the 1998 environmental programs demonstrate that LLNL is committed to protecting the environment and ensuring that its operations are conducted in accordance with applicable federal, state, and local laws and regulations. The environmental impacts of LLNL operations are minimal and pose no threat to the public or the environment.